

Amendments to the Specification

IN THE ABSTRACT OF THE DISCLOSURE

Attached hereto is a replacement Abstract with markings to show amendments.

IN THE WRITTEN DESCRIPTION

Please replace paragraphs [0001]-[0006] with the following amended paragraphs:

TECHNICAL FIELD

[0001] The present invention relates to plating technology and specifically to an electroless gold plating liquid ~~to obtain~~for obtaining a gold plated film generally with an Au thickness of 0.4  $\mu$ m or more, which is required mainly in gold wire bonding and TAB.

BACKGROUND ART

[0002] As electronic parts, electronic devices and the like trend toward higher densities, electroless gold plating is coming into broader use, particularly since it is applicable to fine wiring. Reasons for this include the fact that circuits required for electrolytic plating around the object to be plated aren't needed because it is electroless, and the fact that it contributes to low-cost, simplified processes.

[0003] However, cyanide baths have been used conventionally for electroless gold plating liquids because of their stability, raising concerns about damages ~~onto~~to the resist. Moreover, the high toxicity of cyanide electroless gold plating liquids has led to demands for non-cyanide processes, but baths such as sulfite baths that do not contain cyanide, for example, tend to decompose easily, and improvements are needed. Under these circumstances, non-cyanide electroless gold plating liquids have already been proposed.

[0004] Japanese Patent Documents 1 to 3 disclosed that an effective way for both bath stability and gold deposition speed of a non-cyanide electroless gold plating liquid is to use a mixed sulfite-thiosulfate complex system as a gold complexing agent and to use an urea compound such as thiourea

as a reducing agent. However, when thiourea is used as a reducing agent, it is oxidized and a non-water-soluble cyanamide polymer is produced, causing problems of plate deposition failure. Therefore, as effective countermeasures, the addition of amine and carboxylic acid components for the aim of water-solubilizing the oxidation intermediate and addition of aliphatic saturated alcohol to suppress the autolysis of the thiourea reducing agent are proposed.

[0005] Moreover, Patent Document 4 states that the addition of a mercaptobenzothiazole compound with the aim of suppressing contamination by metal impurities and improving bath stability is useful when using the aforementioned mixed complexing agent together with ascorbic acid as the reducing agent, however, the reduction efficiency by ascorbic acid is poor, which needs to be added in excess to ensure a practical deposition speed (Patent Document 5). Patent Document 5 suggests the complexing agent system as described above, an aromatic compound typified by hydroquinone as a reducing agent system, and a heavy metal compound such as thallium nitrate in order to improve the deposition speed, but, the use of heavy metals, such as thallium, is desired to be substituted with other safer substances from the view point of toxicity, like cyanide.

Patent Document 1: Japanese Patent Publication No. H9-287077

Patent Document 2: Japanese Patent Publication No. H5-78854

Patent Document 3: Japanese Patent Publication No. H11-12753

Patent Document 4: Japanese Patent No. 3148428

Patent Document 5: Japanese Patent Publication No. 2003-268559

#### DISCLOSURE OF THE INVENTION

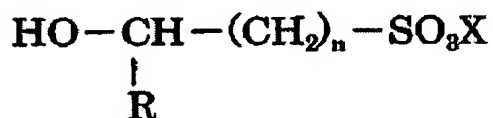
[0006] It is an object of the present invention to provide an electroless gold plating liquid which has an adequate deposition speed for practical use without containing thallium or other heavy metal ions, and which does not require a complicated bath composition or control such as the addition of a water-solubilizing agent or autolysis-suppressing agent as thiourea reducing agents for example. It is also an object of the present invention to provide an electroless gold

plating liquid which has an adequate deposition speed for practical use without containing thallium or other heavy metal ions, and which has a better plating liquid stability than thiourea reducing agents.

Please replace paragraph [0008] with the following amended paragraph:

[0008] (1) An electroless gold plating liquid comprising a non-cyanide gold salt as a gold salt, an alkali metal salt or an ammonium salt of sulfurous acid and thiosulfuric acid as a complexing agent for gold, a hydroxyalkylsulfonic acid or a salt thereof represented by the following general formula as a reducing agent, and an amine compound,

{Chemical Formula 1}

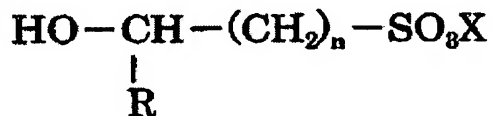


{wherein R represents hydrogen, a carboxyl group, or any of a phenyl group, a tolyl group, a naphthyl group, a saturated or unsaturated alkyl group, an acetyl group, an acetonyl group, a pyridyl group and a furyl group which may have a substitutional group, X represents any of hydrogen, Na, K, and NH<sub>4</sub>, and n is an integer between 0 and 4.}

Please replace paragraph [0013] with the following amended paragraph:

[0013] A hydroxyalkylsulfonic acid or a salt thereof represented by the following general formula is used as the reducing agent:

{Chemical Formula 2}



{wherein R represents hydrogen, a carboxyl group, or any of a phenyl group, a tolyl group, a naphthyl group, a saturated or unsaturated alkyl group, an acetyl group, an acetonyl group, a pyridyl group and a furyl group which may have a

substitutional group, X represents any of hydrogen, Na, K, and NH<sub>4</sub>, and n is an integer between 0 and 4.†

Please replace paragraph [0025] with the following amended paragraph:

[0025] Examples of the amine compound include compounds having primary and secondary amines in one molecule such as diethylenetriamine, triethylenetetramine, tetraethylenepentamine, pentaethylenehexamine, monoamine compounds such as methylamine, ethylamine, propylamine, butylamine, pentanamine, hexanamine, and diamine compounds such as diaminemethylenediamine, ethylenediamine, propylenediamine, butylenediamine, pentanediamine and hexanediamine.

Other examples include aromatic amines having an aromatic ring such as a benzene ring or other bound to the aforementioned compounds, and aromatic amine compounds such as aniline having directly-bound amino groups.

Other examples include aminocarboxylic acids such as glycine and alanine.

Moreover, compounds having a high-polarity substitutional group such as a hydroxyl group, a carboxyl group or a sulfonic acid group bound to the aforementioned compounds or compounds forming a salt such as hydrochlorides can also be used to improve the solubility in water.

Please replace paragraphs [0029] and [0030] with the following amended paragraphs:

[0029] It is desirable from the standpoint of gold deposition rate, plating coat appearance and bath stability that the pH of the gold plating liquid of the present invention be 5 to 9, and a pH of 6 to 8 is particularly desirable.

Alkaline compounds such as potassium hydroxide, sodium hydroxide and ammonia, and acid compounds such as sulfuric acid and phosphoric acid can be used to adjust the pH.

It is desirable from the standpoint of bath stability and gold deposition rate that the gold plating liquid of the present invention be used at a bath temperature of 60 to 90°C.

[0030] When plating with the gold plating liquid of the present invention, the material to be plated, such as a printed circuit board, is dipped in the bath. The material to be plated has preferably first been plated with a nickel undercoat or a ~~subsequent~~subsequently displaced gold coat, and when plating is performed by using the gold plating liquid of the present invention, an adequate deposition rate for practical use is obtained, and the resulting gold plate coat has a good appearance. Plating liquid stability, which was a problem in the past, is also excellent.

Please replace paragraphs [0033]-[0037] with the following amended paragraphs:

[0033] The measuring methods and evaluation methods adopted in the electroless plating methods of the following examples and comparative examples are as follows.

~~{Method to measure of measuring plating rate}~~

The weights of the test piece before and after the electroless gold plating test were measured with an electronic force balance capable of measuring to 0.1 mg, and the thickness of the gold was calculated. The calculation formula is as follows:

Gold thickness ( $\mu\text{m}$ ) = (final weight (g) - initial weight (g))  $\times$  10,000 ( $\mu\text{m}/\text{cm}$ )  $\div$  density of gold ( $19.3 \text{ g}/\text{cm}^3$ )  $\div$  area ( $15.8 \text{ cm}^2$ ).

[0034] ~~{Method of evaluating appearance}~~

Color, irregularities and luster were evaluated visually after the plating test. The color of the test piece after plating was judged to be gold if it had a gold color with the deep metal luster of gold based on the color after electroless displacement gold plating. It was not considered gold if it exhibited any brown or reddish color, but was instead described as yellow-brown or reddish-yellow for example. Gold was the only color seen in the current test results.

The presence or absence of irregularities was evaluated at least as strictly as color judgment. The rolled copper foil already had some irregularities, and irregularities due to electroless nickel plating and electroless displacement gold plating were also distinguished when observing. However, there were judged to be no irregularities in all cases in the current test results.

The test pieces after electroless displacement gold plating exhibited luster, and based on this standard it was judged to be no luster in the observation if the luster was inferior to this, but in the present test results there was luster in all cases.

[0035]     {Liquid color}

The color of the plating liquid was evaluated with the naked eye immediately after completion of the electroless gold plating test. The electroless gold plating liquids of the present invention were clear, but, after, the test one appeared slightly bluish.

{Bath decomposition}

Immediately after finishing the electroless gold plating test the test piece was removed from the container, the container was wrapped in wrapping film and stored for a day and a night at the test temperature (70 to 85°C), and after the removal of the film, the occurrence of abnormal gold deposition in the container was examined. As a result, abnormal gold deposition starting from a flaw in the container was seen only in Comparative Example 1. Under the other test conditions, no abnormal gold deposition was observed despite severe storage conditions.

[0036]     {Preparation and testing of electroless gold plating liquids}

Comparative Examples 1 & 2

Plating liquids whose compositions are shown in Table 2 were prepared.

The characteristic differences of Comparative Example 1 were that the plating liquid contained ethylenediamine as a reaction promoter and 8 g/L of hydroquinone as a reducing

agent. The plating rate was fast, 0.96  $\mu\text{m}/\text{H}$ , but the bath decomposed.

In Comparative Example 2, the bath composition comprised ethylenediamine as a reaction promoter but no reducing agent. Although there was no bath decomposition, the plating rate was 0.45  $\mu\text{m}/\text{H}$ , the slowest speed in Tables 2 and 3.

[0037] Examples 1 through 3

In Example 1 in Table 2, the plating liquid comprised sodium hydroxymethanesulfonate as a reducing agent added to the composition of Comparative Example 2. The plating rate was 0.63  $\mu\text{m}/\text{H}$ , 1.4 times ~~than~~that of Comparative Example 2. The bath did not decompose and was extremely stable.

In Example 2 in Table 3, the composition was the same as Example 1 but the bath temperature was 85°C. The plating rate was 0.82  $\mu\text{m}/\text{H}$ , 1.82 times that of Comparative Example 2. Even with the bath temperature raised to 85°C the bath did not decompose and was extremely stable.